Surgical outcomes of 156 spinal accessory nerve injuries caused by lymph node biopsy procedures

Sang Hyun Park, MD, PhD,¹ Yoshua Esquenazi, MD,² David G. Kline, MD,³ and Daniel H. Kim, MD²

¹Department of Anesthesiology and Pain Medicine, Jeju National University Medical School, Jeju, Korea; ²Department of Neurosurgery, The University of Texas Health Science Center at Houston Medical School, Houston, Texas; and ³Department of Neurosurgery, Louisiana State University Health Sciences Center, New Orleans, Louisiana

OBJECT Iatrogenic injuries to the spinal accessory nerve (SAN) are not uncommon during lymph node biopsy of the posterior cervical triangle (PCT). In this study, the authors review the operative techniques and surgical outcomes of 156 surgical repairs of the SAN following iatrogenic injury during lymph node biopsy procedures.

METHODS This retrospective study examines the authors' clinical and surgical experience with 156 patients with SAN injury between 1980 and 2012. All patients suffered iatrogenic SAN injuries during lymph node biopsy, with the vast majority (154/156, 98.7%) occurring in Zone I of the PCT. Surgery was performed on the basis of anatomical and electrophysiological findings at the time of the operation. The mean follow-up period was 24 months (range 8–44 months).

RESULTS Of the 123 patients who underwent graft or suture repair, 107 patients (87%) improved to Grade 3 functional or higher using the Louisiana State University Health Science Center (LSUHSC) grading system. Neurolysis was performed in 29 patients (19%) when the nerve was found in continuity with recordable nerve action potential (NAP) across the lesion. More than 95% of patients treated by neurolysis with positive NAP recordings recovered to LSUHSC Grade 3 or higher. Forty-one patients (26%) underwent end-to-end repair, while 82 patients (53%) underwent graft repair, and Grade 3 or higher recovery was assessed for 90% and 85% of these patients, respectively. The average graft length used was 3.81 cm. Neurotization was performed in 4 patients, 2 of whom recovered to Grade 2 and 3, respectively.

CONCLUSIONS SAN injuries present challenges for surgical exploration and repair because of the nerve's size and location in the PCT. However, through proper and timely intervention, patients with diminished or absent function achieved favorable functional outcomes. Surgeons performing lymph node biopsy procedures in Zone I of the PCT should be aware of the potential risk of injury to the SAN.

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KEY WORDS lymph node biopsy; nerve action potential; nerve injury; nerve repair; spinal accessory nerve; iatrogenic injury

THE posterior cervical triangle (PCT) is an ideal access point for many surgeons to perform a lymph node biopsy. The lymph nodes of the neck are superficial in this zone and relatively simple to extract compared with the nodes in other areas of the neck, which are generally covered by abundant fibrous and fatty tissues. Due to the close relationship between the lymph nodes and the spinal accessory nerve (SAN), approximately 3% to 10% of all lymph node biopsy procedures result in SAN injuries.¹ SAN injury results in loss of motor function of

the trapezius muscle and leads to weakness of the shoulder in abduction, dropping of the shoulder, and winging of the scapula with pain and stiffness in the shoulder girdle. Spontaneous recovery after an SAN injury is reported infrequently, and if the lesion is left untreated, it will lead to pain and functional deficit in 60%–90% of cases.^{1,2} While the critical time for surgical repair after the injury remains unknown, favorable outcomes can be achieved following early surgical management. This report presents 32 years of surgical experience with 156 SAN iatrogenic injuries

ABBREVIATIONS LSUHSC = Louisiana State University Health Science Center; NAP = nerve action potential; PCT = posterior cervical triangle; SAN = spinal accessory nerve; SCM = sternocleidomastoid muscle.

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that were due to cervical lymph node biopsy and required surgical intervention. We present the surgical anatomy and clinical characteristics of the SAN and PCT, as well as operations performed and their outcomes, to provide management guidelines for SAN injuries.

Methods

Patient Population and Evaluation

Between 1980 and 2012, two senior authors (D.G.K. and D.H.K.) surgically managed 156 patients with iatrogenic SAN lesions following cervical lymph node biopsy procedures without spontaneous recovery. Functional outcome after surgical repair of the SAN lesions in relation to the type of surgical repair was assessed. There were 89 men and 67 women, and the mean follow-up period was 24 months (range 8–44 months). The patients' ages ranged from 6 to 74 years (mean 38 years; Table 1).

Each patient's lymph node biopsy incision sites were documented and noted on initial evaluation. Once an injury was diagnosed, the SAN lesions were monitored clinically and by electromyography for several months for signs of early regeneration. Due to the nature of our practice, only those patients who experienced unsuccessful conservative management and for whom spontaneous regeneration did not occur were referred to us for evaluation. Therefore, patients who required surgical intervention made up the cohort for this study ($n = 156$); a control group was not available. Surgical exploration was performed on all patients, which included intraoperative stimulation and nerve action potential (NAP) recordings to evaluate the degree of physical continuity for each lesion to determine the need for repair by nerve grafts, end-to-end sutures, neurolysis, or neurotization.

Before and after surgery, each patient underwent a thorough clinical assessment of SAN motor function. Functional assessment included measurement of active abduction of the shoulder; manual testing of the trapezius muscle; and evaluation of the contour, function, and strength of the trapezius muscle. The contraction of the trapezius and its ability to stabilize the scapula during a complete arc of abduction were also assessed and compared with those of the normal side.

The study used the Louisiana State University Health Science Center (LSUHSC) grading system to document the degree of the injury for each patient as follows: a grade of 0 (none) was given when muscle contraction was clinically absent; 1 (trace) when muscle contraction was clinically evident but limited to a flicker of movement; 2 (poor)

when some portion of the arc of abduction movement was possible with gravity eliminated; 3 (fair) when the arc of abduction against gravity was at 90° or better; 4 (good) when strength of abduction against gravity and some resistance were possible; and 5 (excellent) when strength of abduction was against moderate-to-full resistance (Table 2). Each patient's initial functional impairment and recovery at the time of each follow-up evaluation were assessed. Grade 3 or better recovery was considered a favorable functional outcome.

Anatomy of the SAN

The SAN is only 1 to 2 mm in diameter and originates from both a cranial and spinal root.^{6,19} The cranial root arises from the vagal nuclei and innervates some of the muscles of the soft palate and larynx.⁹ The spinal root arises from the spinal accessory nucleus within the C1–5 vertebrae and innervates the sternocleidomastoid muscle (SCM) and trapezius muscles. Damage occurs more commonly to the spinal portion of the SAN than to the cranial portion.

The path of the SAN is variable, but generally travels in a line through Zones I and II of the PCT (Fig. 1). It exits the skull through the jugular foramen, and lies lateral to the internal jugular vein and immediately anterior to the transverse process of the atlas vertebra.^{9,14} The nerve runs from the posterior or lateral border of the SCM beginning near the muscle's origin from the mastoid process at an average length of 6.13 cm.¹⁷ Here the SAN is very superficial, lying in the deep cervical fascia embedded in fibroadipose tissue and lymph nodes,¹⁹ and near the great auricular nerve, which wraps around the lateral border of the SCM cephalad.

The SAN and great auricular nerve form an important landmark for surgeons.¹⁶ The cephalad portion of the SAN has been identified to be 0.5 cm to 1.5 cm superior to the egress of the great auricular nerve at the posterior border of the SCM.¹³ The nerve point, which is where the bundle of sensory nerves (C-2, C-3, and C-4) from the cervical plexus arises from beneath the posterior border of the SCM, is also an important anatomical landmark for locating the SAN.⁹ In the PCT, the SAN assumes a coiled S-shape when it is relaxed. The shape of the nerve allows flexibility when the head is turned, and it straightens when

TABLE 1. Demographics and follow-up period for 156 surgical patients with SAN lesions due to cervical lymph node biopsy (1980–2012)

Variable	Value
Sex	
Males	89
Females	67
Mean age in yrs (range)	38 (6–74)
Mean follow-up in mos (range)	24 (8–44)

TABLE 2. Functional assessment grades

Grade*	Evaluation	Description
0	None	Muscle contraction was clinically absent
1	Trace	Muscle contraction was clinically evident but limited to a flicker of movement
2	Poor	Some portion of the arc of abduction movement was possible w/ gravity eliminated
3	Fair	Arc of abduction against gravity was at 90° or better
4	Good	Strength of abduction against gravity and some resistance were possible
5	Excellent	Strength of abduction was against moderate-to-full resistance

* Based on the LSUHSC grading system.

FIG. 1. Illustration of the PCT divided into Zones I–III. The SAN is most susceptible to iatrogenic injury in Zones I and II; Zone III is the recommended cervical lymph node biopsy site. Copyright Daniel H. Kim. Published with permission. Figure is available in color online only.

the shoulder is simultaneously lowered.^{6,7} By the time the SAN runs through the posterior triangle, it is the only source of motor supply to the trapezius. The general extracranial length of the SAN varies from 7 cm to 18.5 cm, with a mean ($\pm$ SD) length of 12.02 ± 2.32 cm.⁴

Posterior Cervical Triangle

After supplying the SCM on its deep surface, the SAN emerges from its posterior border to enter the PCT.¹⁷ The PCT can be divided into 3 zones (Fig. 1), where Zones I and II represent areas in which the SAN is susceptible to injury.

Cadaveric studies have reported variation in the course of the SAN across the posterior triangle.⁶ In 1 study of 25 cadavers, the nerve ran inferiorly and laterally to the anterior border of the trapezius in 74% of the cadavers, and inferiorly and laterally in a tortuous line in 26% of the cadavers.¹⁷ In 14 of the dissections, the nerve ran anteriorly along the border of the trapezius toward the clavicle for several centimeters before entering the muscle.¹⁷ In a more recent study of 10 adult human cadavers, all of the SANs had a straight gross configuration proximal to the PCT and a tortuous appearance within the PCT.¹⁸

The SAN passes obliquely beneath the deep fascia on the levator scapulae, where the C-2 and C-3 vertebrae provide neural contributions.¹⁹ The nerve lies superficial and close to cervical lymph nodes in this area, and it is here that a SAN injury will result in major trapezius motor loss. The SAN supplies short branches to the trapezius along the superior and posterior border of the neck and longer branches to descend into the thoracic portion of the muscle. At the edge of the trapezius, the SAN is approximately 2.7 ± 0.9 cm caudal to the cricoid cartilage.⁶ The length of

the SAN in the PCT has been reported to range from 1.5 to 9 cm, with a mean length of 5.27 ± 1.52 cm and a depth of less than 0.4 cm.^{4,6}

Posterior Cervical Triangle Lymph Node Chain

About 300 of the approximately 800 lymph nodes in the human body reside in the neck area, running roughly vertically through its structures (Fig. 2). The size of a lymph node varies from 3 mm to 25 mm in diameter.²⁰ The level II area of the neck, where the PCT is located, is an impor-

FIG. 2. Posterior cervical lymph node chain (green) and course of the SAN. Copyright Daniel H. Kim. Published with permission. Figure is available in color online only.

tant area for neck dissection because approximately 25% of cervical lymph nodes are in this area. These nodes have a site-specific drainage pattern and the chain of nodes there communicate with the inferior and superior ends of the jugular nodal chain by the transverse cervical node group.¹⁵ As shown in Fig. 2, throughout its path in the PCT to the investing layer of the deep cervical fascia, the SAN lies within fibrofatty tissue and courses superficially to a chain of 4 to 23 lymph nodes.^{4,9,15,20} Afferents of the spinal accessory nodes in this area originate from the occipital, postauricular, and suprascapular nodes.

Surgical Procedures

Surgery was performed under general anesthesia without the use of paralytic agents, enabling identification of the proximal nerve stump with nerve stimulation. The incision for lymph node biopsy with resultant SAN palsy was extended or turned into a Z-shaped incision by adding a limb either superiorly or inferiorly. This extension allows proximal exposure of the SAN and distal exposure of its branches as they reach the trapezius muscle (Fig. 3). The SAN usually exits between the lateral border of the sternomastoid and cleidomastoid muscles just superior to the point where the auricular sensory branch runs over the SCM. This branch can be easily identified during the initial stages of dissection because it curves around the posterior border of the SCM. The proximal stump of the SAN is usually found approximately 1–2 cm superior to this nerve branch. The proximal stump or branches should be preserved during the procedure. The branches from the SAN to the trapezius may be very short. If the injury is close to the border of the trapezius, sometimes it will be required to find viable fascicles distal to the injury into which grafts can be placed. If a lesion in continuity is discovered, external neurolysis is performed and standard electrical and microscopic criteria are used to decide for or against resection based on intraoperative NAP recording across the lesion.

In general, it is appropriate to resect soft tissue and scar proximal and distal to the lesion and work toward the

main pathology. For SAN injuries in the PCT, this can be a difficult maneuver because a mixture of scar and adipose tissue often lies in the upper part of the PCT between the posterior border of the SCM and the anterior border of the trapezius. Dissection under the operating microscope or magnifying loupes may take considerable time as the surgeon distinguishes the cervical plexus and other sensory branches to the skin of the neck and periaural regions.

The soft tissue and/or scar must be searched on the anterior border of the trapezius to find fascicles or branches indicating motor entry points. This is especially important where a length of the SAN has been resected at the time of lymph node removal. The proximal nerve runs between the sternomastoid and cleidomastoid bellies of the SCM, and a neuroma may be buried there in adipose and fibrous tissue. The proximal and distal stumps are prepared using the standard method (Fig. 4 upper). If mobilization of 2 proximal and distal stumps can be brought together without significant tension, end-to-end anastomosis can be achieved with 8-0 nylon sutures (Fig. 4 lower). This procedure is superior to nerve grafting when possible and especially when the transection is relatively clean, because the structure can be aligned.

Nerve grafting is preferred when the SAN is lacerated. Likewise, transection requires grafting if the nerve ends cannot be brought together without tension. A sural nerve is preferred if nerve grafting is chosen, and it should be divided beneath the fascia in the lower leg.¹ The donor graft length should be chosen to allow ample movement of the patient's neck after surgery and also allow for shrinkage of the graft substance.

Results

Within a 32-year period, 156 patients with iatrogenic SAN injuries resulting from cervical lymph node biopsy procedures were evaluated and found to require surgical repair. Of these 156 patients, 154 (99%) sustained injury during a biopsy procedure in Zone 1 of the PCT, where the nerve is most at risk for damage. Table 3 shows the

FIG. 3. Intraoperative photograph of a previous lymph node biopsy (yellow arrow) in Zone I of the PCT (right). The SAN is located at a point two-thirds of the distance (double arrows) starting from the clavicular insertion of the SCM to the mastoid process SCM origin. The incision for lymph node biopsy can be extended or turned into a Z-shaped incision by adding a limb either superiorly or inferiorly. Figure is available in color online only.

FIG. 4. Intraoperative photographs. **Upper:** Exposure of the proximal and distal stumps of a transected SAN. **Lower:** End-to-end repair of the transected SAN is performed. Figure is available in color online only.

types of surgical procedures performed in each of the 156 patients and Table 4 shows patient improvement by grade for those who were followed up for 12 months or more ($n = 152$).

Twenty-nine patients underwent neurolysis because the nerve was in continuity and showed intraoperative electrical evidence of regeneration, such as a positive NAP beyond the point of injury or trapezius contraction in response to SAN stimulation. Grade 3 or better functional recovery was noted in 28 (97%) of these patients (Table 4). Nine of these patients reached Grade 5. All of these patients experienced eventual dramatic improvement in arm abduction and normalization of shoulder posture.

A total of 123 patients with lesions not in continuity or with lesions in continuity but in which NAPs could not be recorded underwent either end-to-end suture (41 patients) or interposition graft repair (82 patients). The average graft length was 3.81 cm. Of these 123 patients, 107 (87%) achieved a Grade 3 or better functional recovery after surgery (Table 4). Of the 41 patients who underwent end-to-end repair, 37 (90%) recovered to Grade 3 or better, which was slightly higher than the patients receiving graft repair (85%). Most of the end-to-end repairs were performed secondarily in more sharply transected SANs. Postoperative outcomes did not differ between the patients

TABLE 3. Surgical procedures performed in 156 patients to repair extracranial SAN injury due to cervical lymph node biopsy

Procedure	No. of Patients
Graft	82
End-to-end repair	41
Neurolysis	29
Neurotization (C2–3)	4
Total	156

who received local grafts compared with those who received sural grafts.

Four patients underwent neurotization when the proximal nerve trunk could not be identified. In this procedure, the contribution of the C-2 and/or C-3 nerves to the SCM was “swung down” to the trapezius and sewn to grafts that were attached to distal accessory branches. The results of neurotization were not as remarkable as for the other performed procedures, but still substantial. Two of the 4 patients who underwent neurotization experienced some degree of recovery. From a preoperative Grade 0, these 2 patients improved to Grades 2 and 3 after an average follow-up of 15 months.

Discussion

Cervical lymph node biopsy is the most common cause of iatrogenic SAN injury, with an incidence of 3%–10%.¹ The SANs superficial location in Zone I of the PCT, where most biopsy procedures are performed, places the nerve at risk for injury and palsy, which results in winging of the scapula and difficulty with shoulder abduction. Such injuries rarely undergo spontaneous regeneration, and generally require surgical intervention to repair the nerve. In this study of 156 patients with SAN injuries during cervical lymph node biopsy, 154 received their injury in this area. The SAN emerges from the posterior or lateral border of the SCM through Zones I and II of the PCT. In Zone I, the nerve is superficial and is embedded in cervical lymph nodes and fibroadipose tissue, making it susceptible to iatrogenic injury (Fig. 5). In some cases, the nerve is also attached to the underside of the epidermis, making its manipulation necessary to access the tissues of this zone. The SAN location makes it susceptible to stretching and laceration injuries, hence surgeons should use great caution when performing lymph node biopsies in this area. The average length of the nerve at this point is 3.5 cm, after which it descends into the tissues in Zone II before passing into the thoracic portion of the trapezoid muscle. The SAN is generally absent in Zone III of the PCT. A SAN injury should be suspected if a patient has pain or stiffness in the shoulder and a history of an operation in the neck region, such as a lymph node biopsy or neck dissection.¹³ For suspected SAN injuries, examination of the function of the SAN should be performed to make a timely diagnosis. The initial complaint of shoulder pain in patients with SAN injuries may be misdiagnosed as glenohumeral instability or muscle injury.¹¹ Other diagnoses that should be ruled out include cervical radiculopa-

TABLE 4. Functional assessments of patients before and after surgical intervention*

Grade	Neurolysis (n = 29)		End-to-End Repair (n = 41)		Local Graft (n = 82)	
	Preop	Postop†‡	Preop	Postop†§¶	Preop	Postop†§**
5	0	9	0	6	0	11
4	0	12	0	25	0	50
3	0	7	0	6	0	9
2	0	1	0	3	0	6
1	7	0	8	1	9	4
0	22	0	33	0	73	2

* Grades in functionality for patients completing follow-up of 12 months or more (n = 152).

† One hundred thirty-five (89%) of 152 patients who underwent neurolysis, end-to-end, or graft repair recovered to Grade 3 or higher.

‡ Twenty-eight (97%) of 29 patients who underwent neurolysis recovered to Grade 3 or higher.

§ One hundred seven (87%) of 123 patients who underwent end-to-end or local graft repair reached Grade 3 or higher.

¶ Thirty-seven (90%) of 41 patients who underwent end-to-end repair recovered to Grade 3 or higher.

** Seventy (85%) of 82 patients who underwent a local graft procedure recovered to Grade 3 or higher.

thy, brachial plexopathy/neuritis, and long thoracic nerve palsy, which cause some combination of shoulder girdle depression, limited shoulder motion, and cervical/scapular pain.⁵ Some physicians erroneously rule out SAN injury if the patient can shrug his or her shoulders, but the levator scapula muscle normally assists the trapezius muscle in this function and can therefore produce a shrug on the affected side.¹

Presenting symptoms of SAN injuries are not subtle

and occur either immediately after the procedure or soon afterward. These symptoms include pain over the affected muscle; a feeling of heaviness or “dragging” in the arm; an inability to abduct the arm beyond the horizontal plane and to elevate the arm for more than a few seconds; and finally, numbness over the angle of the jaw and around the ear, sometimes caused by associated damage to the greater auricular nerve.^{10,19}

In this study, pain was a common complaint; most patients experienced the onset of pain immediately or within 1 week of their lymph node biopsy. Arm pain and occipital and posterior neck discomfort was occasionally associated with this pain, and the pain was typically described as a constant, dull ache that was sometimes severe. These symptoms may be a result of chronic shoulder depression that creates tension on the shoulder joint or elements of the brachial plexus. As the muscle atrophies, the ligaments stretch and the musculoskeletal structure on the affected side shifts, putting additional stress on the surrounding muscles and structures.

Scapular winging caused by accessory palsy can be differentiated from long thoracic palsy by using the “flip test.” In this test, the patient stands with his or her arm at the side, and the elbow is flexed to 90°. The examiner resists glenohumeral external rotation at the distal forearm while visually examining the scapula. A positive scapular flip sign occurs when the medial scapular border “flips” up, or lifts from the thoracic wall during resisted shoulder external rotation.⁵ The flip sign is also present in patients with a partial return of the upper trapezius, which acts as an upward rotator and elevator. Therefore, even when active, it cannot oppose the pull of the humeral external rotators. The middle and lower trapezius muscles also appear to stabilize the scapular medial border during resisted humeral external rotation; even when intact, the rhomboids are unable to properly perform this duty during the assessment. In contrast, pushing forward against resistance with the hand and arm and a fully extended elbow does not produce severe winging, which typically occurs in long thoracic palsy.

A review of 11 studies of patients who underwent surgical management of their SAN injuries reported clinical recovery rates ranging from 50% to 100%.¹ The 156

FIG. 5. Illustration of a cross-section of the neck showing the SAN is covered solely by skin and fascia in the PCT. Lymph nodes are usually close by the SAN. Copyright Daniel H. Kim. Published with permission. Figure is available in color online only.

patients selected for surgical intervention in the present study had complete or nearly complete loss of trapezius muscle function, with denervation, as assessed by electromyography. Of the 152 patients who were followed for 12 or more months postsurgery, 89% recovered to Grade 3 or better for functional activity. Neurolysis was performed in patients with lesions in continuity that were regenerating as shown by positive NAP recordings with favorable functional outcomes in almost all of the cases. Lesions not in continuity or lesions in continuity but in which NAPs could not be recorded underwent either end-to-end suture or interposition graft repair with a high percentage of favorable outcomes. End-to-end epineural repair was performed if an injured nerve was transected or unable to transmit an NAP and a short nerve gap after resection existed. When the gap was too large for end-to-end repair or if the nerve was badly fibrosed or embedded in heavy scar tissue, autografts were harvested and interfascicular repair was performed. The donor nerves for these grafts were harvested from the local cervical sensory nerve or greater auricular nerve if it was suitable in caliber and quality, or in other cases a sural nerve graft was used. Postoperative outcomes of the patients who received local grafts and those who received sural grafts did not differ. Although postoperative grades for the 4 patients who underwent neurotization were lower relative to results of the other surgical procedures performed, 2 of the 4 patients experienced substantial recovery. In 34 nonoperative cases followed by the authors previously and reported in 2008, spontaneous recovery was poor if the initial grades were 2 or less by the LSUHSC system.¹² Also, it should be noted that full nerve transfer has been reported to be less effective in pain relief or restoration of muscle function, and it should only be undertaken where repair or grafting cannot be performed.³

Whereas previous studies have reported SAN injuries and outcomes,^{8,12} the current large case series study focuses exclusively on iatrogenic injuries due to cervical lymph node biopsy for which spontaneous recovery was absent and surgical management indicated. Early detection of SAN injury is key to monitoring the nerve and developing a treatment plan. Because the nerve seldom spontaneously regenerates, early surgery is recommended to avoid significant atrophy of the trapezius and long-term functional deficits. In our experience, patients who undergo surgical repair within 3–6 months of injury have better functional outcomes than patients who present beyond 8–12 months of the injury. The difference in outcomes between these patients is mostly related to the degree of muscle atrophy that occurs over time following the injury. This large series of patients with SAN injuries following cervical lymph node biopsy spans more than 3 decades and represents a relatively common clinical problem. While this study warrants greater awareness of the risk for SAN injury during cervical lymph node biopsy, it also demonstrates the favorable functional outcomes that can be achieved following SAN repair if managed correctly.

Conclusions

Although neck dissections in the PCT have been modi-

fied in recent years to preserve the SAN, iatrogenic injuries still occur in as many as 10% of cervical lymph node biopsy procedures. Surgeons who operate in this area should have a thorough knowledge of the anatomy of the PCT and be aware of the risk of injury of the SAN, particularly in Zone I. While some patients may improve with conservative management, surgical exploration is indicated for SAN injuries that do not demonstrate clinical or electrical signs of recovery for up to 3 months after the injury. As shown in this study, appropriate and timely surgical exploration and repair of iatrogenic damage to the SAN following lymph node biopsy can result in favorable outcomes.

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Author Contributions

Conception and design: Kim, Kline. Acquisition of data: Kim, Park. Analysis and interpretation of data: Kim, Park, Esquenazi. Drafting the article: all authors. Critically revising the article: Kim, Esquenazi, Kline. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Kim. Study supervision: Kim, Kline.

Correspondence

Daniel H. Kim, Department of Neurosurgery, Memorial Hermann Health System, The University of Texas Health Science Center, 6400 Fannin, Ste. 2150, Houston, TX 77030. email: daniel.h.kim@uth.tmc.edu.